



# The SO2 Allowance Trading System: The Ironic History of a Grand Policy Experiment

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**HARVARD Kennedy School**  
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# **The SO<sub>2</sub> Allowance Trading System: The Ironic History of a Grand Policy Experiment**

## **Faculty Research Working Paper Series**

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**THE SO<sub>2</sub> ALLOWANCE TRADING SYSTEM:  
THE IRONIC HISTORY OF A GRAND POLICY EXPERIMENT**

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# **The SO<sub>2</sub> Allowance Trading System: The Ironic History of a Grand Policy Experiment**

Richard Schmalensee and Robert N. Stavins

## **ABSTRACT**

Two decades have passed since the Clean Air Act Amendments of 1990 launched a grand experiment in market-based environmental policy: the SO<sub>2</sub> cap-and-trade system. That system performed well but created four striking ironies. First, by creating this system to reduce SO<sub>2</sub> emissions to curb acid rain, the government did the right thing for the wrong reason. Second, a substantial source of this system's cost-effectiveness was an unanticipated consequence of earlier railroad deregulation. Third, it is ironic that cap-and-trade has come to be demonized by conservative politicians in recent years, since this market-based, cost-effective policy innovation was initially championed and implemented by Republican administrations. Fourth, court decisions and subsequent regulatory responses have led to the collapse of the SO<sub>2</sub> market, demonstrating that what the government gives, the government can take away.

**Key Words:** market-based instruments, cap-and-trade, Clean Air Act amendments of 1990, sulfur dioxide, acid rain

**JEL Classification Codes:** Q540, Q580, Q400, Q480

# **The SO<sub>2</sub> Allowance Trading System: The Ironic History of a Grand Policy Experiment**

Richard Schmalensee and Robert N. Stavins<sup>1</sup>

Two decades have passed since the Clean Air Act Amendments of 1990 (CAAA) were signed into law, launching a grand experiment in market-based environmental policy. By the late 1980s, there was growing concern in the United States and other countries that acid precipitation – the result of sulfur dioxide (SO<sub>2</sub>) and, to a lesser extent, nitrogen oxides (NO<sub>x</sub>) reacting in the atmosphere to form sulfuric and nitric acids – was damaging forests and aquatic ecosystems. In the United States, flue gas emissions from coal-fired, electric generating plants were the primary source of SO<sub>2</sub> emissions and a major source of NO<sub>x</sub> emissions. In response to this and other concerns, the U.S. Congress passed and President George H. W. Bush signed into law the CAAA, Title IV of which established the path-breaking SO<sub>2</sub> allowance trading program.

While the concept of cap-and-trade is now broadly familiar, in 1990 this market-based approach to regulating the environment was quite novel. Some were hostile to the notion of trading “rights to pollute”; others doubted its workability. Up until that time, nearly all pollution regulations took a much more prescriptive, “command-and-control” approach, either by setting uniform emission rate limits on classes of emitters or by specifying the type of pollution-control equipment to be installed. Such requirements are relatively inflexible, imposing the same abatement path upon a range of generally heterogeneous facilities and ignoring the fact that the costs of compliance might vary widely across individual facilities depending on their age, technology characteristics, operating conditions, and characteristics of fuel used.

By the close of the twentieth century, the SO<sub>2</sub> allowance trading system had come to be seen as both innovative and successful. It has become exceptionally influential, leading to a series of policy innovations in the United States and abroad to address a range of environmental challenges, including the threat of global climate change (Stavins 2003). Most prominent among these innovations has been the European Union Emission Trading System, a carbon dioxide (CO<sub>2</sub>) cap-and-trade system adopted in 2003 that is by far the world’s largest environmental pricing regime (European Commission 2012).

The design and implementation of the landmark SO<sub>2</sub> cap-and-trade system have led to four striking ironies that are the focus of this essay. First, subsequent research indicates that in enacting an ambitious – and successful – policy to reduce SO<sub>2</sub> emissions in order to curb acid rain, the government essentially did the right thing for the wrong reason. Second, although the program appears to have been successful on nearly all dimensions, a substantial source of its cost-effectiveness was an unanticipated consequence of the deregulation of railroad rates in the late 1970s and early 1980s. Third, it is ironic that cap-and-trade has come to be demonized by conservative politicians in the last few years, since this market-based, cost-effective policy innovation was championed and implemented by Republican administrations from that of President Ronald Reagan to that of President George W. Bush. Fourth and finally, court decisions and subsequent regulatory responses have led to the virtual collapse of the SO<sub>2</sub> market, demonstrating that what the government gives, the government can take away. In order to explain these four ironies, we first briefly review highlights of the system’s design and performance.

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A fifth, long-recognized irony deserves brief mention. Acid rain itself was largely a consequence of compliance with national ambient air quality standards set in the 1970s for SO<sub>2</sub> and other localized pollutants. In order to reduce local ambient concentrations, electric utilities built more than 400 tall stacks, many greater than 500 feet in height (Regens and Rycroft 1988), which successfully dispersed the stack gases, but did so by injecting them high enough into the atmosphere that they precipitated out tens or hundreds of miles downwind as acidified rain, snow, or particles.

## Design

The policy's objective was to reduce total annual U.S. SO<sub>2</sub> emissions by 10 million tons relative to 1980. (This section draws on Chan *et al.* 2012; also see Ellerman *et al.* 2000.) Phase I (1995–1999) required significant emissions reductions from the 263 most polluting coal-fired electric generating units, almost all located east of the Mississippi River. Phase II, which began in 2000, placed an aggregate national emissions cap of 8.95 million tons per year on approximately 3,200 electric generating units — nearly the entire fleet of fossil-fueled plants in the continental United States (Ellerman *et al.* 2000). This cap — affecting almost exclusively the power sector — represented a 50 percent reduction from 1980 levels.

The government gave permits to emit, called allowances, denominated in tons of SO<sub>2</sub> emissions, to power plants covered by the law. If annual emissions at a regulated facility exceeded the allowances allocated to that facility, the owner could buy allowances or reduce emissions, whether by installing pollution controls, changing the mix of fuels used to operate the facility, or by scaling back operations. If emissions at a regulated facility were reduced below its allowance allocation, the facility owner could sell the extra allowances or bank them for future use. These opportunities created incentives to find ways to reduce emissions at the lowest cost and to take advantage of low-cost abatement options early.

While this policy is seen by many observers as one of the most successful applications of economic thinking to environmental policy, the policy's target was not chosen to maximize net economic benefits. (This is true of most environmental policies, of course.) No credible estimates of economic benefits at alternative target levels were available. Instead, the target was selected largely based on what was believed to be the “elbow” of the abatement cost curve. Also, there was a political desire to choose a target level of reductions that was big enough to gain the support of the environmental community and to be seen as satisfying a campaign pledge of the new President. Thus the choice of the cap was consistent with a positive political economy model of policy making whereby a politically acceptable target is chosen with an eye toward avoiding regions of steep change in the policy's impact on social welfare (Baumol and Oates 1971).

After the target level of emissions, the second most important design feature of the system was its allocation of allowances. Government auctioning of allowances would have generated revenue that could have been used – in principle – to reduce distortionary taxes, thereby reducing the program's social cost (Goulder 1995). But this efficiency argument was not advanced at the time; affected utilities and their customers' representatives would have strongly opposed auctioning; and the political value of being able to allocate free allowances to address distributional concerns was substantial (Joskow and Schmalensee 1998). Also, because cost-of-service regulation characterized the entire electric utility industry in 1990, it was assumed that the value of free allowances would be passed on to consumers and not generate windfall profits for providers. Given that a free allocation was utilized, the distribution could be defined in such a way as to ensure the greatest political support, without fear that this would jeopardize the system's environmental performance or economic cost. Absent particularly problematic types of transaction costs (Stavins 1995; Hahn and Stavins 2011), a cap-and-trade system's equilibrium allocation after trading is independent of the initial allocation (Coase 1960; Montgomery 1972).

## Performance

Beginning in 1995 and over the subsequent decade, the SO<sub>2</sub> allowance-trading program performed exceptionally well along all relevant dimensions. (Early assessments of the system's design and performance were provided by Schmalensee et al 1998 and Stavins 1998.) The program was environmentally effective, with SO<sub>2</sub> emissions from electric power plants decreasing 36 percent – from 15.9 million to 10.2 million tons – between 1990 and 2004 (U.S. Environmental Protection Agency 2011b), even though electricity generation from coal-fired power plants *increased* 25 percent over the same period (U.S. Energy Information Administration 2011). The program's long-term goal of reducing annual nationwide utility emissions to 8.95 million tons was achieved in 2007, and by 2010 emissions had declined further, to 5.1 million tons. Overall, the program delivered emissions reductions more quickly than expected, as utilities took advantage of the possibility of banking allowances. With its \$2,000/ton statutory fine for any emissions exceeding allowance holdings (and continuous emissions monitoring), compliance was nearly 100 percent.

The costs of achieving these environmental objectives with cap-and-trade were significantly less than they would have been with a command-and-control regulatory approach. Cost savings were at least 15 percent and perhaps as much as 90 percent, compared with counterfactual policies that specified the means of regulation in various ways and for various portions of the program's regulatory period (Carlson *et al.* 2000; Ellerman *et al.* 2000; Keohane 2003). In addition to static cost effectiveness, there is evidence that the program brought down abatement costs over time by providing incentives for innovation in equipment and operating procedures that are generally much stronger than those provided by traditional command-and-control regulation (Ellerman *et al.* 2000, pp. 235-48; Popp 2003; Bellas and Lange 2011).

While the program was less costly than a conventional approach, the costs may not have been as low as they could have been. Marginal abatement costs varied significantly across facilities, at least in the program's first two years (Carlson *et al.* 2000). On the other hand, there is evidence that the intertemporal allocation of abatement cost (via allowance banking) was at least approximately efficient (Ellerman and Montero 2007), and the pattern of voluntary compliance was consistent with cost-effective compliance strategies (Montero 1999).

The following factors may have kept costs above the theoretical minimum, though the influence of each has been debated: (1) provisions in the CAAA that encouraged early use of flue-gas desulfurization (using devices called “scrubbers”) instead of switching to low-sulfur coal – in an effort to limit impacts on high-sulfur coal producers (Ellerman *et al.* 2000, pp. 301-2); (2) lack of information about marginal abatement costs on the part of market participants, particularly in the early years; (3) state regulation that, particularly in the early years of the program, had the effect of distorting or constraining utilities' responses to federal environmental regulation (Arimura 2002; Bohi and Burtraw 1992; Ellerman *et al.* 2000, pp. 190-5); (4) interactions between the SO<sub>2</sub> program and other federal regulations, such as New Source Review and New Source Performance Standards, which constrained the program's operation; and (5) policy uncertainty when regulators and policy makers subsequently considered further reductions in the national SO<sub>2</sub> cap, as we discuss later.

The program can also be evaluated based on the geographic distribution of impacts. Most coal-fired power plants were located east of the Mississippi, and model-based analyses predicted that the largest share of emissions reductions would come from the Midwest and East. There was some concern that emissions would end up disproportionately concentrated, and that this, combined with prevailing wind patterns, would result in “hot spots” of unacceptably high SO<sub>2</sub> concentrations. Despite these concerns, however, the program did not generate significant hot spots (Ellerman *et al.* 2000, pp. 130-1; Swift 2004), though recent work (Muller and Mendelsohn 2009) suggests that the use of damage-based trading ratios, rather than a single allowance price, could have been welfare-improving.

In sum, the SO<sub>2</sub> allowance-trading system's actual costs, even if they exceeded the cost-effective ideal for a cap-and-trade system, were much lower than would have been incurred with a comparable traditional regulatory approach, and the program's goals were achieved with less litigation (and thus more certainty) than is typical for traditional environmental programs. There is broad agreement that the SO<sub>2</sub> allowance-trading system provided a compelling demonstration of the advantages of a market-based approach to environmental protection. With this background on design and performance, we turn to four significant ironies.

## Doing the Right Thing for the Wrong Reason

In the years leading up to the enactment of the Clean Air Act Amendments of 1990, there was great concern in the United States about acid rain, in particular about the acidification of forests and aquatic ecosystems. Thus, the central purpose of the SO<sub>2</sub> allowance-trading program was to reduce precursor SO<sub>2</sub> emissions in order to reduce acid rain, primarily in the northeastern United States (National Acid Precipitation Assessment Program 1998). This was accomplished – SO<sub>2</sub> emissions were dramatically cut. However, it turns out that the ecological benefits of the program have been relatively small – largely because it takes much longer than thought to reverse the acidification of ecosystems (National Acid Precipitation Assessment Program 2005) – while other, completely unanticipated benefits of the program have been massive.

Whereas some studies at the time of the program's enactment predicted that its benefits would be approximately equal to its costs (Portney 1990), more recent estimates have pegged annual benefits at between \$59 and \$116 billion, compared with annual costs of \$0.5 to 2 billion (Table 1). More than 95 percent of these benefits are associated not with ecological impacts (including acidification of aquatic ecosystems), however, but with human health impacts of reduced levels of airborne fine sulfate particles less than 2.5 micrometers in diameter (PM<sub>2.5</sub>) derived from SO<sub>2</sub> emissions. Epidemiological evidence of the harmful human health effects of these fine particulates mounted rapidly in the decade *after* the CAAA was enacted (Chestnut and Mills 2005).

Estimates of these health benefits vary widely, but they appear to be on the order of \$50 billion to more than \$100 billion per year (Burtraw *et al.* 1998; Burtraw 1999; Chestnut and Mills 2005; National Acid Precipitation Assessment Program 2005; Shadbegian, Gray, and Morgan 2005; U.S. Environmental Protection Agency 2011a). As Table 1 shows, strict ecosystem benefits are probably considerably less than program costs, though at least one study (Banzhaf *et al.* 2006) suggests that ecosystem benefits alone have exceeded program costs. In any case, estimated human health benefits of the program have exceeded annual costs by a factor of more than fifty! The government did what turned out to be the right thing for the wrong reason.

## An Unanticipated Consequence of Deregulation

In addition to being less costly than traditional command-and-control policies would have been, the realized costs of the SO<sub>2</sub> allowance trading program were substantially less than *ex ante* forecasts prior to implementation (National Acid Precipitation Assessment Program 2005).<sup>2</sup> While part of this discrepancy was due to technological innovation and the speed with which the allowance market matured, a major factor in low realized compliance costs was the emergence of input substitution, from high to low sulfur coal, as a cost-effective compliance strategy. And, interestingly, the attractiveness of switching to

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<sup>2</sup> A revolutionary aspect of the cap-and-trade approach was that for the first time regulators had instantaneous information in a summary statistic (the allowance price) of the marginal cost of compliance, but the program's design did not allow for any response to that information, such as changing the cap.



low sulfur coal was increasing *before* the program even went into effect, due to a public policy change – unrelated to the environment – initiated long before the CAAA of 1990.

Prior to 1976, the Interstate Commerce Commission (ICC) set rates for freight rail. Then, the Railroad Revitalization and Regulatory Reform Act of 1976 and the Staggers Rail Act of 1980 gave rail carriers the ability to set their own rates, and legalized private railroad-shipper contracts. The result was that shipping rates for coal (and other products) declined dramatically (Winston 2005; U.S. Government Accountability Office 2007). This brought with it a substantial fall in the cost of bringing coal from the Powder River Basin in Wyoming and Montana to centers of high demand east of the Mississippi River, relative to the costs of coal from the Midwest and Appalachia (Ellerman *et al.* 2000) – even though the existence of only two major rail lines kept shipping costs above competitive levels (Busse and Keohane 2008).

The three major coal deposits in the United States are located in the Powder River Basin (PRB), the Illinois Basin and Central Appalachia. Of these, PRB coal is cheapest to mine and has the lowest sulfur content, though considerable low-sulfur coal was also produced in the East, particularly after the acid rain program took effect. Hence, absent the use of any abatement technology, switching from high-sulfur eastern coal to low-sulfur coal, particularly PRB coal, reduces power plant SO<sub>2</sub> emissions per unit of electricity generation.

The majority of coal-fired power plants in the United States are located along or east of the Mississippi River, making PRB the most distant option for major sources of demand. As freight prices fell with deregulation, liberalization gave freight carriers flexibility and incentive to contract with eastern utilities, and these same utilities developed low-cost ways to modify their boilers (which were designed to burn bituminous coal) to burn sub-bituminous PRB coal (Ellerman *et al.* 2000, pp. 243-45). The average sulfur content of coal burned at electric generating units began to fall. In fact, SO<sub>2</sub> emissions at units covered by the allowance-trading program were actually falling from 1985 to 1993, before the acid rain program took effect (Ellerman and Montero 1998). The main source of this decline was the increased use of PRB coal, with average rail rates of shipping PRB coal to Midwest generators falling by over 50 percent from 1979 to 1993 (Gerking and Hamilton 2008).

For some power plants, this made fuel-switching from high-sulfur to low-sulfur coal cost-effective even in the absence of the acid rain legislation; and for many other eastern power plants, it made fuel-switching less expensive than installing scrubbers in response to the legislation. Of the 263 units regulated in the first phase of the allowance-trading program, 52 percent primarily pursued fuel switching or blending low-sulfur coal with higher-sulfur coal, accounting for 59 percent of emissions reductions; and scrubbers were installed at about 10 percent of the units, accounting for 28 percent of emissions reduction (U.S. Energy Information Administration 1997).<sup>3</sup> Overall, it appears that about one-third of SO<sub>2</sub> emissions reductions in the early years of the program were due to prior railroad deregulation and two-thirds to the SO<sub>2</sub> allowance trading program (Ellerman *et al.* 2000, p. 122).

It could be argued that because these reductions in delivered fuel costs would have occurred in the absence of the SO<sub>2</sub> allowance trading program — and would have reduced the costs of a command-and-control SO<sub>2</sub> program as well — the cost savings attributed to the SO<sub>2</sub> allowance-trading program (relative to a command-and-control system) should be adjusted downward (Carlson *et al.* 2000). This is valid, but it is also true that a prescriptive regulatory approach – such as a policy that required the installation of scrubbers at all power plants – might have prevented electricity companies from taking advantage of some of these alternative compliance options.

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<sup>3</sup> In addition, 32 percent of the units complied by obtaining additional allowances as well as switching to lower-sulfur coal, accounting for 9 percent of emissions reductions; 3 percent of the units were retired, accounting for 2 percent of emissions reductions; and 3 percent of the units used other compliance methods, accounting for 2 percent of emissions reductions (U.S. Energy Information Administration 1997).

In any event, it is clear that significant shares of the emissions reduction – about one-third in the early years – and of the cost savings associated with the SO<sub>2</sub> allowance trading system were actually an unanticipated consequence of an earlier, unrelated public policy change.

## **Conservatives Demonize Their Own Innovation**

Some two decades after the Clean Air Act Amendments of 1990 were signed into law by President George H. W. Bush, the U.S. House of Representatives passed legislation – H.R. 2454, the American Clean Energy and Security Act of 2009 or the Waxman-Markey bill – that included an economy-wide cap-and-trade system to cut carbon dioxide (CO<sub>2</sub>) emissions linked with global climate change. But, one year later, in July of 2010, the U.S. Senate abandoned its attempt to pass companion legislation.

In the process of considering this legislation, conservative Republicans (and some coal-state Democrats) attacked the cap-and-trade system as “cap-and-tax.” They may have been helped by President Obama’s January 2009 budget message to Congress, which provided for revenues from an auction of 100 percent of the allowances under such a scheme (Chan, Stavins, Stowe, and Sweeney 2012). Regardless of what they thought about climate change, there was significant irony to this demonization of market-based approaches to environmental protection, since these policies were innovations developed by conservatives in the Reagan, George H. W. Bush, and George W. Bush administrations – and once strongly condemned by liberals and environmentalists.

In the 1980s, President Ronald Reagan’s Environmental Protection Agency put in place a trading program to phase out leaded gasoline. It produced a more rapid elimination of leaded gasoline from the marketplace than had been anticipated, and at a savings of some \$250 million per year, compared with a conventional no-trade, command-and-control approach (Stavins 2003). Not only did President George H. W. Bush successfully propose the use of cap-and-trade to cut U.S. SO<sub>2</sub> emissions, his administration advocated in international fora the use of emissions trading to cut global CO<sub>2</sub> emissions, a proposal initially resisted but ultimately adopted by the European Union. In 2005, President George W. Bush’s EPA issued the Clean Air Interstate Rule, aimed at reducing SO<sub>2</sub> emissions by a further 70 percent from their 2003 levels. Cap-and-trade was again the policy instrument of choice in order to keep costs down and achieve rapid reductions at minimum economic pain. (This rule was later invalidated by the courts, as we discuss below.)

When the CAAA was being considered in the U.S. Congress, environmental and energy debates typically broke along geographic lines (with key parameters being degree of urbanization and reliance on specific fuel types, such as coal versus natural gas). Support and opposition were both largely bipartisan. The CAAA passed the Senate in 1990 by a vote of 89-11 with 87 percent of Republican members and 91 percent of Democrats voting yea, and it passed the House of Representatives by a vote of 401-21 with 87 percent of Republicans and 96 percent of Democrats voting in support.

Such bipartisan voting patterns were typical for environmental issues in the 1970s through much of the 1990s. But by the time climate change legislation received serious consideration in Washington in 2009-2010, environmental politics – and partisan politics more generally – had changed dramatically, with Congressional voting on environmental legislation typically taking place along strictly partisan lines. The Waxman-Markey legislation was passed by the House of Representatives in 2009 by a vote of 219-212, with support from 83 percent of Democrats, but only 4 percent of Republicans.

This polarization between the two political parties on environmental issues (Shipan and Lowry 2001) was (and is) part of a gradual widening gulf between the parties on virtually all issues (Fleisher and Bond 2004). The polarization has shown up in studies by political scientists employing a diverse set of measures that place members of Congress on an ideological spectrum from extreme right to extreme left

based on their roll-call votes (Poole and Rosenthal 1997, 2007). Polarization – the gradual disappearance of moderates – has been taking place for decades (Lowry and Shipan 2002; Theriault 2008). The rise of the Tea Party movement within the Republican Party is only the most recent episode in a much longer story.

Four structural factors have been considered as possible contributors to this trend. First, there has been the increasing importance of the primary system, a consequence of the “democratization” of the nomination process that began in the 1970s (Bartels 1988, Ansolabehere, Snyder, and Stewart 2001). A small share of the electorate vote in primaries, namely those with the strongest political preferences: the most conservative Republicans and the most liberal Democrats (Burden 2001). This self-selection favors candidates from the extremes (King, Orlando, and Sparks 2011). Second, decades of redistricting have produced more and more districts that are dominated by either Republican or Democratic voters (Carson, Crespin, Finocchiaro, and Rohde 2007; Ansolabehere and Snyder 2002), which further increases the importance of primary elections. Third, geographic sorting of like-minded households may have furthered this trend. Fourth, the increasing cost of electoral campaigns greatly favors incumbents (Carson, Engstrom, and Roberts 2007), with the ratio of average incumbent-to-challenger financing now exceeding 10-to-1. This tends to make districts relatively safe for the party that controls the seat, thereby further increasing the importance of primaries.

These factors operate mainly when new members of Congress are elected (Theriault 2006). To a lesser degree, polarization has also taken place through the adaptation of sitting members of Congress: in order to discourage or survive primary challenges, Republican members shift rightward and Democratic members shift leftward. A striking recent example of this shift is the evolution of Senator John McCain, Republican of Arizona, from a moderate during his 2008 Presidential run to a solid conservative in 2010 in response to a primary challenge from a Tea Party candidate.

The Great Recession of the past several years, like the Great Depression of the 1930s, has undoubtedly increased political polarization (McCarty, Poole, and Rosenthal 2006). The 1930s saw not only the rise of American socialists and communists, but also the rise of American right-wing extremism. It may be that better economic times will reduce the pace of political polarization. However, in the face of the long-term structural factors noted above, it is difficult to be optimistic about the long-term prognosis.

Many conservatives in the Congress undoubtedly opposed climate policies because of disagreement about the threat of climate change or the costs of the policies, but instead of debating risks and costs, they chose to launch an ultimately successful campaign to demonize and thereby tarnish cap-and-trade as an instrument of public policy, rendering it “collateral damage” in the wider climate policy battle. This scorched-earth approach could come back to haunt conservatives if future environmental initiatives with widespread support are enacted without making use of the power of the marketplace to reduce compliance costs. It is ironic that conservatives chose to demonize their own market-based creation. It is perhaps even more ironic that this tactic seems to have been effective despite their creation’s excellent performance.

## **What the Government Gives, It Can Take Away**

A major source of uncertainty about any government-created market is that the government can undo what it created — possibly unintentionally. In essence, this is what has happened in the SO<sub>2</sub> allowance market.

Prices for SO<sub>2</sub> allowances were remarkably stable throughout the program’s first decade (Figure 1). But in 2004, prices began to rise, ultimately topping \$1,200/ton in 2005. Why did this happen? It was widely recognized by the late 1990s that SO<sub>2</sub> reductions in excess of those resulting from the trading

program of Title IV would be required by other provisions in the Clean Air Act and would in any event be warranted, given the significant adverse health effects of fine particulates associated with SO<sub>2</sub> emissions. But Title IV did not give EPA authority to adjust the program, such as by tightening the overall cap, in response to new information about the benefits (or costs) of emissions reductions. This led to a chain of events that ultimately brought about the virtual collapse of the SO<sub>2</sub> allowance trading program.

In early 2002, President George W. Bush proposed the Clear Skies Act, which would have greatly tightened the SO<sub>2</sub> cap. The lack of an initial allowance market reaction suggests it was no surprise when this proposal died in March 2005, having failed to move out of committee. The Administration then promulgated its Clean Air Interstate Rule (CAIR) in May, 2005, with the same purpose of lowering the cap on SO<sub>2</sub> emissions (to 70 percent below the 2003 emissions level). CAIR did this in part by applying more stringent emission requirements on states that were contributing to violations of EPA's primary ambient air quality standards for fine particulates in the eastern United States (Palmer and Evans 2009). It required sources within those states to surrender two additional allowances for every ton of SO<sub>2</sub> emissions, effectively reducing the cap by two-thirds. Because CAIR provided that firms could bank their SO<sub>2</sub> allowances for use in the new program, prices rose further in anticipation of CAIR's more stringent cap, with spot prices increasing from \$273 per ton in EPA's 2004 auction to \$703 in the 2005 auction (Figure 1).<sup>4</sup>

After peaking in 2005 at more than \$1,200 per ton, SO<sub>2</sub> allowance prices dropped just as fast as they had risen, aided by EPA's announcement that it would re-examine CAIR (Samuelsohn 2005) and speculation about impending legal challenges (Samuelsohn 2006a; Kruse 2009).<sup>5</sup> The speculation was proven to be correct on June 26, 2006, when North Carolina and other states and a number of utilities sued EPA over CAIR (Samuelsohn 2006b). The states argued that the interstate trading allowed under CAIR was inconsistent with a provision in the Clean Air Act that obliges each state to prevent emissions that interfere with any other state's attainment or maintenance of air quality standards.

Two years later, on July 11, 2008, the Circuit Court of Appeals for the District of Columbia responded to the lawsuit by vacating CAIR in its entirety, and thereby invalidating the core of prior SO<sub>2</sub> regulation, the cap-and-trade system with unlimited trading across states, by asserting that under the Clean Air Act EPA did not have authority to ignore the relationship between sources and receptors (U.S. Environmental Protection Agency 2011a). On that single day, the SO<sub>2</sub> allowance price fell from \$315 to \$115 (Figure 1) (Burtraw and Szambelan 2009). The Bush administration – and the subsequent Obama administration – chose not to appeal that ruling. In December, the court allowed CAIR to remain in effect while EPA devised a replacement that addressed its concerns, but it remained clear that unlimited interstate trading was doomed. Expectations of a more stringent SO<sub>2</sub> cap, which had fueled the run-up in allowance prices, became less defensible, and prices continued to fall, returning to the range of their pre-

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<sup>4</sup> An array of other factors contributed to the run-up and eventual spike in SO<sub>2</sub> allowance prices, including: Hurricanes Katrina (August, 2005) and Rita (September 2005), which impaired petroleum refining and natural gas capacity. In addition, delivery of low-sulfur coal from the Powder River Basin to Midwestern power plants was disrupted by track failures (May, 2005) on both the Union Pacific and Burlington Northern Santa Fe railroads, which caused low-sulfur coal prices in the Midwest to peak in December, 2005, at a level three times greater than a year earlier. This led some power companies to switch to higher sulfur coal from the east, increasing demand for SO<sub>2</sub> allowances. A final factor was features of the allowance trading program's design that interacted with the tax system and utility regulation to restrict the number of allowances actually available for trading at any time (the "float"), thus compounding the price impacts of the other factors (Parsons, Ellerman, and Feilhauer 2009).

<sup>5</sup> Also contributing to the fall in allowances prices from their peak was a drop in natural gas prices, the restoration of refining and gas capacity in the Gulf of Mexico following Hurricanes Katrina and Rita, and the realization of a likely adequate supply of allowances and installed scrubber capacity to comply with CAIR (Burtraw and Szambelan 2009). In addition, the expectation of an economy-wide CO<sub>2</sub> cap-and-trade system, which all three major Presidential candidates – John McCain, Hilary Clinton, and Barak Obama – in 2007 supported, would have led to an exogenous, long-run decline in SO<sub>2</sub> emissions as well, and hence to a decline in the value of banked allowances.

2004 levels. At EPA's 2009 auction, spot allowances (which could be used in 2009 or later) sold for \$70 per ton, compared with \$390 a year earlier (Burtraw and Szambelan 2009).

In July, 2010, the Obama Administration proposed its Clean Air Transport Rule (CATR) to limit annual SO<sub>2</sub> (and NO<sub>x</sub>) emissions in 28 states, as a replacement for the CAIR. The proposed rule established state-specific emissions caps for power plant SO<sub>2</sub> emissions, limiting inter-state trading. The rule was finalized in July, 2011, as the Cross-State Air Pollution Rule (CSAPR), allowing only intrastate trading and limited trading between two groups of states. (Predictably, this rule has also been challenged in court, by 27 states and 18 other parties, and in January 2012 the D.C. Circuit Court ordered EPA to keep CAIR in force pending its review of CSAPR.)

The shift from CAIR to CSAPR was the death-knell for the SO<sub>2</sub> allowance trading program, though the program remains nominally in place, since it dramatically reduced the scope for cost-effective interstate trades. The SO<sub>2</sub> market collapsed, with allowance prices falling to record low levels. By the time of EPA's 2012 auction, market-clearing prices had fallen to \$0.56 in the spot auction and \$0.12 in the seven-year advance auction.<sup>6</sup>

In essence, the imposition of state-level and source-specific prescriptive regulation has all but eliminated the demand for allowances. States with binding caps under CSAPR have no alternative but to reduce their emissions, whether by mandating the use of scrubbers, retiring coal-fired power plants, or setting up intrastate trading. Either way, the demand for federal SO<sub>2</sub> allowances has been virtually eliminated.

While the SO<sub>2</sub> allowance market functioned effectively, the broader regulatory environment served to end its life prematurely. (One more irony: the program's success may have weakened the case for continuing the allowance market by reducing the heterogeneity of abatement costs across sources, thus reducing potential gains from trade (Newell and Stavins 2003).) When the government creates a market, it can also destroy it, possibly fostering a legacy of increased regulatory uncertainty and reduced investor confidence in future cap-and-trade regimes, and hence reduced credibility of pollution markets more broadly.

## Conclusions

More than twenty years after the Clean Air Act amendments of 1990 launched the path-breaking SO<sub>2</sub> allowance trading system, the world's first large-scale market-based environmental initiative, that grand experiment in public policy continues to enjoy its reputation around the world as a great success. Although it is true that the system performed at least as well as its optimistic advocates had anticipated through its first decade of operation – reducing emissions cost-effectively – it is also true that reflecting now on this performance yields a considerably more nuanced assessment.

Although the emissions-reduction cap was indeed achieved, the program had originally been intended to reduce damages to forests and aquatic ecosystems caused by acid rain, and the system has accomplished considerably less in that regard than had been anticipated. At the same time, however, actual costs of compliance have been substantially less than originally expected. Even more striking is that the real benefits of the program are both much greater than its costs and very different in kind from those that were anticipated. Rather than providing significant ecological benefits, reductions in SO<sub>2</sub> emissions under the allowance trading system have resulted in dramatic decreases in downwind

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<sup>6</sup> When new Mercury and Air Toxics Standards (MATS) affecting coal-fired power plants take effect – likely in 2015-2016 – they will likely be so stringent that SO<sub>2</sub> constraints under CSAPR will be rendered non-binding in one of the two SO<sub>2</sub> trading zones. Further, the MATS explicitly do not allow trading, and so assuming these rules are finalized and implemented as expected, there will be only a minimal market for SO<sub>2</sub> (Burtraw, *et al.* 2012).

concentrations of small particulates, thereby producing great benefits to human health, particularly reductions in mortality. Hence, it is fair to say that the government did what turned out to be the right thing for the wrong reason.

Despite the worldwide celebration of the success of this cap-and-trade system, it now appears that some part of that success in reducing SO<sub>2</sub> emissions at low cost was due not to allowance trading but to the earlier deregulation of U.S. railroads. This reduced the delivered cost of low-sulfur coal from the Powder River Basin to the Midwest, and so provided economic incentives for substitution of this “clean coal” for the high-sulfur coal mined in the eastern part of the country. A significant share of the SO<sub>2</sub> emissions reductions associated with the CAAA was actually an unintended consequence of other, non-environmental policy innovations, and the availability of this low-cost compliance option was a major factor in the system’s cost-effectiveness.

Market-based systems, such as cap-and-trade, would seem to be a quintessential Republican approach to environmental protection. Indeed, history has validated this, with Ronald Reagan’s lead trading system at the heart of his phasedown of leaded gasoline in the 1980s, George H. W. Bush’s SO<sub>2</sub> allowance-trading system and international advocacy of cap-and-trade in the 1990s, and George W. Bush’s Clear Skies proposal and Clean Air Interstate Rule in the current century. But more recent history and politics surrounding potential public policies to reduce CO<sub>2</sub> emissions linked to global climate change have exhibited a very different pattern. With political polarization having reached high levels, the environment is no longer a regional, bipartisan issue in Washington, but a decidedly and decisively partisan one, with conservatives – largely Republicans – coming to be strongly opposed to national climate legislation. In the process of opposition, they have demonized cap-and-trade proposals as “cap-and-tax” and have thereby tarnished this market-based approach to environmental protection. If the tarnish cannot be removed, the cost of future environmental programs may be needlessly increased.

Ironically, an attempt to render more stringent the government’s SO<sub>2</sub> emissions cap through the use of a separate, but related cap-and-trade system eventually led through a series of court cases and regulatory responses to the virtual closure of the SO<sub>2</sub> allowance market. Because of increasing concerns about the human health impacts of fine particles, the George W. Bush administration included SO<sub>2</sub> targets in its multi-pollutant Clear Skies legislation in 2002. The Congress failed to act on the legislation, and so the Bush administration instead proposed tightening the CAAA cap in its Clean Air Interstate Rule or CAIR, in 2005. That approach was invalidated by the courts in 2008, because it did not prevent interstate transmission of pollution, and the Obama administration’s proposed replacement, finalized in 2011 as the Cross-State Air Pollution Rule, would virtually eliminate interstate trading, the source of most of the potential gains from trade. As a result, the SO<sub>2</sub> allowance trading system has essentially come to an end. What the government gives, it can take away.

What are the implications of this history of the SO<sub>2</sub> allowance trading program for future environmental policy, including for climate change? The good news, which this program clearly demonstrated, is that cap-and-trade is not just a subject of seminars and journal articles; it is a viable option for tackling large-scale environmental problems. Even if the SO<sub>2</sub> allowance trading program’s performance was enhanced by unanticipated benefits and declines in coal prices, and even if it has been essentially wiped out by later policy changes, the fact is that the allowance trading program achieved its target emissions reductions rapidly and cost-effectively. Few other environmental programs of any sort have performed as well.

The bad news is that “cap-and-tax” rhetoric may make it hard to use this approach in the U.S. to deal with climate change. This is bad news indeed. Emissions of CO<sub>2</sub> from coal-fired power plants will no doubt be reduced by EPA rules on SO<sub>2</sub>, NO<sub>x</sub>, mercury, coal fly-ash, and cooling-water withdrawals that are working their way through the regulatory process, and that will drive up the cost of generating electricity with coal. But these rules, and those likely to be adopted by the EPA in response to the requirement that it regulate CO<sub>2</sub> under the Clean Air Act, are unlikely to be cost-effective policies for

reducing greenhouse gas emissions. At a time when environmental protection in general and climate policy in particular have become highly polarized in the U.S. Congress, the outlook for an efficient and effective national climate policy is not good. In particular, the tarnishing of cap-and-trade by conservatives as a potential instrument of action may make it even more difficult to give serious consideration in the future to this and other market-based approaches to environmental protection.

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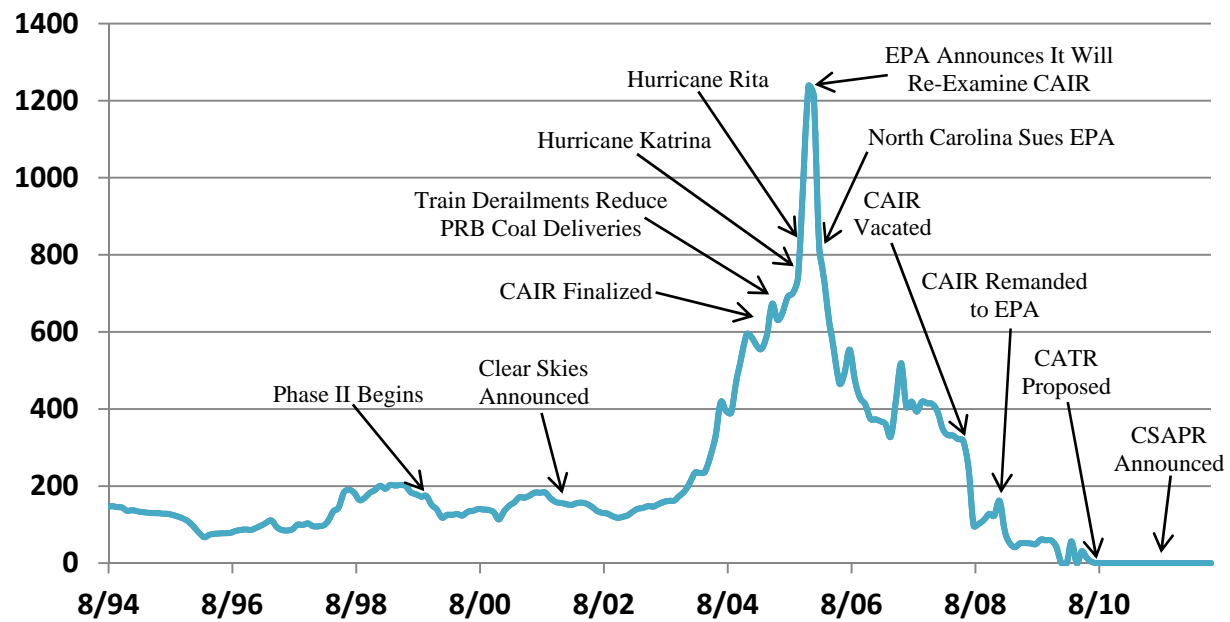
**Table 1: Estimated Annual U.S. Benefits and Costs of the SO<sub>2</sub> Allowance Trading Program; Title IV, Clean Air Amendments of 1990**  
(Billions of U.S. 2000 Dollars)

<b>Benefits</b>	Mortality	\$ 50 – 100
	Morbidity	3 – 7
	Recreational Visibility	2 – 3
	Residential Visibility	2 – 3
	Ecosystem Effects	0.5
	Total Annual Benefits	59 – 116
<b>Costs</b>		0.5 – 2.0
<b>Net Benefits</b>		58 – 114

*Source:* Burtraw et al. (1998); Burtraw (1999); Chestnut and Mills (2005); Banzhaf *et al.* (2006).



**Figure 1: SO<sub>2</sub> Allowance Prices and the Regulatory Environment, 1994-2012**  
(1995 \$ per ton)



*Source:* Data on spot prices compiled by Power & Energy Analytic Resources (PEAR) Inc. from Cantor Fitzgerald until September 11, 2001, and from ICAP United thereafter.

## REFERENCES

- Ansolabehere, Stephen, and James M. Snyder, Jr.** 2002. "The Incumbency Advantage in U.S. Elections: An Analysis of State and Federal Offices, 1942-2000." *Election Law Journal* 1(2):315-338.
- Ansolabehere, Stephen, James M. Snyder, Jr., and Charles Stewart, III.** 2001. "Candidate Positioning in U.S. House Elections." *American Journal of Political Science* 45(1):136-159.
- Arimura, Toshi H.** 2002. "An Empirical Study of the SO<sub>2</sub> Allowance Market: Effects of PUC Regulations." *Journal of Environmental Economics and Management*, 44(2):271-289.
- Banzhaf, H. Spencer, Dallas Burtraw, David Evans, and Alan Krupnick.** 2006. "Valuation of Natural Resource Improvements in the Adirondacks." *Land Economics* 82(3):445-464.
- Bartels, Larry M.** 1988. *Presidential Primaries and the Dynamics of Public Choice*. Princeton, New Jersey: Princeton University Press.
- Baumol, William J., and Wallace E. Oates.** 1971. "The Use of Standards and Prices for Protection of the Environment." *Swedish Journal of Economics*, 73(1):42-54.
- Bellas, Allen S., and Ian Lange.** 2011. "Evidence of Innovation and Diffusion Under Tradable Permit Programs." *International Review of Environmental and Resource Economics*, 5(1):1-22.
- Bohi, Douglas R., and Dallas Burtraw.** 1992. "Utility Investment Behavior and the Emission Trading Market." *Resources and Energy*, 14(1-2):129-53.
- Burden, Barry C.** 2001. "The Polarizing Effects of Congressional Primaries." *Congressional Primaries and the Politics of Representation*, ed. P. F. Galderisi, M. Ezra, and M. Lyons. Lanham: Rowman & Littlefield Publishers.
- Burtraw, Dallas.** 1999. "Cost Savings, Market Performance and Economic Benefits of the U.S. Acid Rain Program. *Pollution for Sale: Emissions Trading and Joint Implementation*, Steve Sorrell and Jim Skea, eds. Cheltenham, United Kingdom: Edward Elgar Publishing, Ltd.
- Burtraw, Dallas, Alan Krupnick, Erin Mansur, David Austin and Deirdre Farrell.** 1998. "Cost and Benefits of Reducing Air Pollutants Related to Acid Rain." *Contemporary Economic Policy* 16(4): 379-400.
- Burtraw, Dallas, and Sarah Jo Szambelan.** 2009. "U.S. Emissions Trading Markets for SO<sub>2</sub> and NO<sub>x</sub>." Discussion Paper 09-40, Resources for the Future, Washington, D.C.
- Burtraw, Dallas, Karen L. Palmer, Anthony Paul, Blair Beasley, and Matthew Woerman.** 2012. "Reliability in the Electricity Industry under New Environmental Regulations." Resources for the Future, Discussion Paper 12-18.
- Carlson, Curtis, Dallas Burtraw, Maureen L. Cropper, and Karen Palmer.** 2000. "Sulfur Dioxide Control by Electric Utilities: What are the Gains from Trade?" *Journal of Political Economy*, 108 (6):1292-1326.
- Carson, Jamie L., Michael H. Crespin, Charles J. Finocchiaro, and David W. Rohde.** 2007. "Redistricting and Party Polarization in the U.S. House of Representatives." *American Politics Research*, 35(6):878-904.

- Carson, Jamie L., Erik J. Engstrom, and Jason M. Roberts.** 2007. "Candidate Quality, the Personal Vote, and the Incumbency Advantage in Congress." *American Political Science Review* 101(2):289–301.
- Chan, Gabriel, Robert Stavins, Robert Stowe, and Richard Sweeney.** 2012. *The SO<sub>2</sub> Allowance Trading System and the Clean Air Act Amendments of 1990: Reflections on Twenty Years of Policy Innovation*. Cambridge, Massachusetts: Harvard Environmental Economics Program.
- Chestnut, Lauraine G., & David M. Mills.** 2005. "A Fresh Look at the Benefits and Costs of the U.S. Acid Rain Program." *Journal of Environmental Management*, 77(3):252–266.
- Coase, Ronald H.** 1960. "The Problem of Social Cost." *Journal of Law and Economics* 3:1–44.
- Ellerman, A. Denny, Paul L. Joskow, Richard Schmalensee, Juan-Pablo Montero, and Elizabeth M. Bailey.** 2000. *Markets for Clean Air: The U.S. Acid Rain Program*. Cambridge, United Kingdom: Cambridge University Press.
- Ellerman, A. Denny, and Juan-Pablo Montero.** 1998. "The Declining Trend in Sulfur Dioxide Emissions: Implications for Allowance Prices." *Journal of Environmental Economics and Management*, 36(1):26–45.
- Ellerman, A. Denny, and Juan-Pablo Montero.** 2007. "The Efficiency and Robustness of Allowance Banking in the U.S. Acid Rain Program." *Energy Journal*, 28(4): 47–71.
- European Commission.** 2012. *Emissions Trading System (EU ETS)*. Available at [http://ec.europa.eu/clima/policies/ets/index\\_en.htm](http://ec.europa.eu/clima/policies/ets/index_en.htm)
- Fiorina, Morris P.** 1999. "Whatever Happened to the Median Voter." Paper presented at the Midwest Political Science Association Annual Meeting, Chicago, Illinois, April 15–17.
- Fleisher, Richard, and John R. Bond.** 2004. "The Shrinking Middle in the U.S. Congress." *British Journal of Political Science*, 34(3):429–451.
- Gerking, Shelby, and Stephen F. Hamilton.** 2008. "What Explains the Increased Utilization of Powder River Basin Coal in Electric Power Generation?" *American Journal of Agricultural Economics* 90(4):933–950.
- Goulder, Lawrence H.** 1995. "Environmental Taxation and the 'Double Dividend': A Reader's Guide." *International Tax and Public Finance* 2(2):157–183.
- Hahn, Robert W., and Robert N. Stavins.** 2011. "The Effect of Allowance Allocations on Cap-and-Trade System Performance." *The Journal of Law and Economics* 54(2), November, 2011, (published August, 2012), pp. S267–S294.
- Joskow, Paul L., and Richard Schmalensee.** 1998. "The Political Economy of Market-based Environmental Policy: The U.S. Acid Rain Program." *Journal of Law and Economics* 41:81–135.
- Keohane, Nathaniel O.** 2003. "What Did the Market Buy? Cost Savings Under the U.S. Tradeable Permits Program for Sulfur Dioxide." Working Paper YCELP-01-11-2003. Yale Center for Environmental Law and Policy, October 15.
- King, Aaron S., Frank J. Orlando, and David B. Sparks.** 2011. "Ideological Extremity and Primary Success: A Social Network Approach." Paper presented at the Annual Meeting of the Midwest Political Science Association.

- Kruse, Elizabeth.** 2009. "North Carolina v. Environmental Protection Agency." *Harvard Environmental Law Review* 33(1):283-296.
- Lowry, William R., and Charles R. Shipan.** 2002. "Party Differentiation in Congress." *Legislative Studies Quarterly* 27:33-60.
- McCarty, Norian, Keith T. Poole, and Howard Rosenthal.** 2006. *Polarized America: The Dance of Ideology and Unequal Riches*. Cambridge, Massachusetts: MIT Press.
- Montero, Juan-Pablo.** 1999. "Voluntary Compliance with Market-Based Environmental Policy: Evidence from the U.S. Acid Rain Program." *Journal of Political Economy*, 107(5): 998-1033.
- Montgomery, W. David.** 1972. "Markets in Licenses and Efficient Pollution Control Programs." *Journal of Economic Theory*, 5(3):395-418.
- Muller, Nicholas Z., and Robert Mendelsohn.** 2009. "Efficient Pollution Regulation: Getting the Prices Right." *American Economic Review*, 99(5):1714-39.
- National Acid Precipitation Assessment Program.** 1998. *Biennial Report to Congress: An Integrated Assessment*. Washington, DC: National Science and Technology Council, Committee on Environment and Natural Resources.
- National Acid Precipitation Assessment Program.** 2005. *National Acid Precipitation Assessment Program Report to Congress: An Integrated Assessment*. Washington, D.C.: National Science and Technology Council, Committee on Environment and Natural Resources.
- Newell, Richard N., and Robert N. Stavins.** 2003. "Cost Heterogeneity and the Potential Savings from Market-Based Policies." *Journal of Regulatory Economics* 23(1):43-59.
- Palmer, Karen, and David A. Evans.** 2009. "The Evolving SO<sub>2</sub> Allowance Market: Title IV, CAIR, and Beyond." *Resources for the Future Weekly Policy Commentary*, July 13.
- Parsons, John E., A. Denney Ellerman, and Stephen Feilhauer.** 2009. "Designing a U.S. Market for CO<sub>2</sub>." *Journal of Applied Corporate Finance*, 21(1):79-86.
- Poole, Keith T., and Howard Rosenthal.** 1997. *Congress: A Political-Economic History of Roll Call Voting*. New York: Oxford University Press.
- Poole, Keith T., and Howard Rosenthal.** 2007. *Ideology and Congress*. New Brunswick: Transaction Publishers.
- Popp, David.** 2003. "Pollution Control Innovations and the Clean Air Act of 1990," *Journal of Policy Analysis and Management*, 22(4):641-660.
- Portney, Paul R.** 1990. "Economics of the Clean Air Act." *Journal of Economic Perspectives*, 4(4):173-181.
- Regens, James L., and Robert W. Rycroft.** 1988. *The Acid Rain Controversy*. Pittsburgh, Pennsylvania: University of Pittsburgh Press.
- Samuelsohn, Darren.** 2005. "EPA Agrees to Re-Examine CAIR Power Plant Standard." *Greenwire*, November 23.
- Samuelsohn, Darren.** 2006a. "Bush Regs Facing a Year of Legal Challenges." *Greenwire*, January 6.

- Samuelsohn, Darren.** 2006b. “North Carolina Sues EPA Over Upwind Emissions.” *Greenwire*, June 27.
- Schmalensee, Richard, Paul L. Joskow, A. Denny Ellerman, Juan-Pablo Montero, and Elizabeth M. Bailey.** 1998. “An Interim Evaluation of Sulfur Dioxide Emissions Trading.” *Journal of Economic Perspectives*, 12(3): 53-68.
- Shadbegian, Ronald J., Wayne B. Gray, and Cynthia L. Morgan.** 2005. “Benefits and Costs from Sulfur Dioxide Trading: A Distributional Analysis.” Working Paper 05-09. Washington, D.C.: U.S. Environmental Protection Agency, National Center for Environmental Economics.
- Shipan, Charles R., and William R. Lowry.** 2001. “Environmental Policy and Party Divergence in Congress.” *Political Research Quarterly* 54:245-263.
- Stavins, Robert N.** 1995. “Transaction Costs and Tradeable Permits.” *Journal of Environmental Economics and Management* 29:133-148.
- Stavins, Robert N.** 1998. “What can we learn from the grand policy experiment? Lessons from SO<sub>2</sub> allowance trading.” *Journal of Economic Perspectives*, 12(3):69–88.
- Stavins, Robert N.** 2003. “Experience with Market-Based Environmental Policy Instruments.” *Handbook of Environmental Economics*, Volume I, eds. Karl-Göran Mäler and Jeffrey Vincent, Chapter 9, pp. 355-435. Amsterdam: Elsevier Science.
- Swift, Byron.** 2004. “Emissions Trading and Hot Spots: A Review of the Major Programs.” *Environment Reporter* 35(19):1–16.
- Theriault, Sean M.** 2006. “Party Polarization in the U.S. Congress: Member Replacement and Member Adaptation.” *Party Politics*, 12(4):483–503.
- Theriault, Sean M.** 2008. *Party Polarization in the Congress*. New York: Cambridge University Press.
- U.S. Energy Information Administration.** 1997. “The Effects of Title IV of the Clean Air Act Amendments of 1990 on Electric Utilities: An Update.” Washington, D.C. [http://www.eia.gov/cneaf/electricity/clean\\_air\\_upd97/exec\\_sum.html](http://www.eia.gov/cneaf/electricity/clean_air_upd97/exec_sum.html) **U.S. Energy Information Administration.** 2011. “Electricity Net Generation: Total (All Sectors), 1949–2010.” <http://205.254.135.24/totalenergy/data/annual/txt/ptb0802a.html>.
- U.S. Environmental Protection Agency.** 2011a. *Clean Air Interstate Rule, Acid Rain Program, and Former NO<sub>x</sub> Budget Trading Program 2010 Progress Report*. Washington, D.C.: U.S. Environmental Protection Agency. [www.epa.gov/airmarkt/progress/ARPCAIR10\\_01.html](http://www.epa.gov/airmarkt/progress/ARPCAIR10_01.html).
- U.S. Environmental Protection Agency.** 2011b. “National Emissions Inventory Air Pollutant Emissions Trends Data: 1970–2011.” [www.epa.gov/ttn/chieftrends/index.html](http://www.epa.gov/ttn/chieftrends/index.html).
- U. S. Government Accountability Office.** 2007. *Freight Railroads: Updated Information on Rates and Other Industry Trends*. Publication No. GAO-07-1245T.
- Winston, Clifford.** 2005. “The Success of the Staggers Rail Act of 1980.” AEI-Brookings Joint Center for Regulatory Studies, Related Publication:05-24.